

AMENDMENTS TO THE CLAIMS:

The listing of claims below will replace all prior versions and listings of claims in the application:

Listing of Claims:

1. (Currently Amended) A method for timing misalignment determination in a radio receiver, comprising the steps of:

~~estimating and correcting a frequency offset and~~ determining a ~~establishing a time reference wherein the boundary between the a short[[-]] and long[[-]] preamble is sufficient in a received radio signal;~~

constructing a real signal from a complex time-domain signal associated with said short preamble;

extracting an n-sample sequence from a portion of said short preamble to obtain a plurality of equidistant equal amplitude frequency peaks wherein n is an integer greater than or equal to zero; and

determining a timing offset estimate by inspecting the relative phases of said plurality of equidistant equal amplitude frequency peaks;

~~wherein, data encoded in said received radio signal may thereafter be demodulated.~~

2. (Currently Amended) The method of Claim 1, wherein:

the step of constructing includes in-phase and quadrature-phase sampling of said received radio signal to obtain a real part and an imaginary part;

wherein said real and imaginary parts are similar to one another except for a fixed time-skew between them.

3. (Original) The method of Claim 2, wherein:

the step of constructing includes a simple addition of said real and imaginary parts to obtain said real signal.

4. (Currently Amended) The method of Claim 1, wherein:

the step of determining is such that the phase of a set of three frequency peaks  $\Phi_1$ ,  $\Phi_2$  and  $\Phi_3$  is assumed to vary with timing misalignment between  $\Delta(t)$  and  $\delta(t)$ , and an intra-baud timing offset  $\tau$  ~~can be~~is derived from  $\Phi_1$ ,  $\Phi_2$  and  $\Phi_3$  wherein, a received signal ~~can be~~is represented by,

$$\begin{aligned}\Psi(t) &= \Phi_1(t) + 2\Phi_2(t) + \Phi_3(t) \\ &= \frac{\pi}{4} \left( 1 + \frac{t}{T_s} \right) + 2 \frac{\pi}{4} \left( 1 + 2 \frac{t}{T_s} \right) + 3 \frac{\pi}{4} \left( -1 + 2 \frac{t}{T_s} \right) \\ &= 2\pi \frac{t}{T_s}\end{aligned}$$

and,  $\Psi = (X_8 P_1)(X_{16} P_2)^2 (X_{24} P_3)$ , where  $X_k$  and  $P_n$  respectively designate 64-point fast Fourier transform frequency components and the phase correcting coefficients needed to compensate for phase offset errors caused by a misalignment between  $\Delta(t)$  and  $\delta(t)$ , and the timing misalignment  $\tau$  is expressed as a fraction of a sampling period,  $T_s$ , and is

$$\tau = \frac{\Psi}{\pi}.$$

5. (Original) The method of Claim 1, wherein:

the step of determining computes a 64-point fast Fourier transform rather than a three-point discrete Fourier transform.

6. (Currently Amended) A method for timing misalignment determination in a radio receiver, comprising the steps of:

determining a boundary between a short preamble and a long preamble in a received radio signal;

linearly combining samples of two long sequences from said long preamble to obtain an idealized sequence of samples that best approaches under a certain criterion an ideal sequence of samples;

computing a normalized dot product of said idealized sequence of samples and an ideal on-baud sampled sequence to obtain a magnitude estimate of any timing misalignment; and

computing a dot product of said idealized sequence of samples and the time derivative of the ideal on-baud sampled sequence mentioned above to obtain a sign of any timing misalignment;

~~wherein data encoded in said received radio signal may thereafter be corrected for timing misalignment and then demodulated.~~

7. (Currently Amended) The method of Claim 6, wherein the steps of linearly combining and computing ~~can use a cost function can be used, and~~ mathematically described by,

$$\begin{aligned}
 C(\alpha_1, \alpha_2) &= \left\| \bar{R}_{on} - \begin{bmatrix} \bar{X}_1 & \bar{X}_2 \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \right\|^2 \\
 &= \left( \bar{R}_{on} - \begin{bmatrix} \bar{X}_1 & \bar{X}_2 \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \right)^H \left( \bar{R}_{on} - \begin{bmatrix} \bar{X}_1 & \bar{X}_2 \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \right) \\
 &= (\bar{R}_{on}^H - \alpha_1^* \bar{X}_1^H - \alpha_2^* \bar{X}_2^H) (\bar{R}_{on} - \alpha_1 \bar{X}_1 - \alpha_2 \bar{X}_2) \\
 &= \|\bar{R}_{on}\|^2 - 2 \operatorname{Re}(\alpha_1^* \bar{X}_1^H \bar{R}_{on}) - 2 \operatorname{Re}(\alpha_2^* \bar{X}_2^H \bar{R}_{on}) + 2 \operatorname{Re}(\alpha_1^* \alpha_2 \bar{X}_1^H \bar{X}_2) + |\alpha_1|^2 \|\bar{X}_1\|^2 + |\alpha_2|^2 \|\bar{X}_2\|^2
 \end{aligned}$$

where,

$\bar{X}_1 = \bar{C}_1 \cdot \times \bar{R}_{off} + \bar{N}_1$  is the first sequence of the long preamble,

$\bar{X}_2 = \bar{C}_2 \cdot \times \bar{R}_{off} + \bar{N}_2$  is the second one,

$\bar{R}_{on}$  and  $\bar{R}_{off}$  respectively designate the on - baud and off – baud sampled reference sequence,  $\alpha_1$  and  $\alpha_2$  are the weighting coefficients,

$$\bar{C}_1 = \begin{bmatrix} e^{j\varphi_1} \\ e^{j2\pi\frac{\nu}{F_s} + j\varphi_1} \\ \vdots \\ e^{j2\pi\frac{\nu}{F_s}63 + j\varphi_1} \end{bmatrix},$$

$$\bar{C}_2 = \begin{bmatrix} e^{j\varphi_2} \\ e^{j2\pi\frac{\nu}{F_s} + j\varphi_2} \\ \vdots \\ e^{j2\pi\frac{\nu}{F_s}63 + j\varphi_2} \end{bmatrix}, \text{ and}$$

$\nu$  designates the frequency offset.

and, minimizing  $C(\alpha_1, \alpha_2)$  with respect to  $\alpha_1$  and  $\alpha_2$  yields,

$$\begin{aligned} \frac{\partial C}{\partial \alpha_1} &= -\bar{R}_{on}^H \bar{X}_1 + \alpha_2^* \bar{X}_2^H \bar{X}_1 + \alpha_1^* \|\bar{X}_1\|^2 \\ &= \sum_{n=0}^{63} R_{on}^*(n) R_{off}(n) e^{j2\pi\frac{\nu}{F_s}n + j\varphi_1} + \alpha_2^* e^{j(\varphi_1 - \varphi_2)} \sum_{n=0}^{63} |R_{off}(n)|^2 + \alpha_1^* (\|\bar{R}_{off}\|^2 + \sigma_N^2) \\ &= -e^{j\varphi_1} P + \alpha_1^* (S + \sigma_N^2) + \alpha_2^* e^{j(\varphi_1 - \varphi_2)} S \end{aligned}$$

$$\begin{aligned} \frac{\partial C}{\partial \alpha_2} &= -\bar{R}_{on}^H \bar{X}_2 + \alpha_1^* \bar{X}_1^H \bar{X}_2 + \alpha_2^* \|\bar{X}_2\|^2 \\ &= -\sum_{n=0}^{63} R_{on}^*(n) R_{off}(n) e^{j2\pi\frac{\nu}{F_s}n + j\varphi_2} + \alpha_1^* e^{j(\varphi_2 - \varphi_1)} \sum_{n=0}^{63} |R_{off}(n)|^2 + \alpha_2^* (\|\bar{R}_{off}\|^2 + \sigma_N^2) \\ &= -e^{j\varphi_2} P + \alpha_1^* e^{j(\varphi_2 - \varphi_1)} S + \alpha_2^* (S + \sigma_N^2) \end{aligned}$$

with:  $\sigma_N^2 = \bar{N}_1^H \bar{N}_1 = \bar{N}_2^H \bar{N}_2$ ,  $S = \sum_{n=0}^{63} |R_{off}(n)|^2$  and  $P = \sum_{n=0}^{63} R_{on}^*(n) R_{off}(n) e^{-j2\pi \frac{\nu}{F_s} n}$ .

8. (Original) The method of Claim 7, wherein the steps of linearly combining and computing assume that  $\bar{N}_1^H \bar{N}_2 = \bar{N}_1^H \bar{X}_2 = \bar{N}_2^H \bar{X}_1 = \bar{N}_1^H R = \bar{N}_2^H R = 0$ , although such is not exactly true in reality, and thereby reduces computer processing required; and continuing with,

$$\begin{aligned} \begin{cases} \frac{\partial C}{\partial \alpha_1} = 0 \\ \frac{\partial C}{\partial \alpha_2} = 0 \end{cases} &\Rightarrow \begin{bmatrix} S + \sigma_N^2 & e^{j(\varphi_1 - \varphi_2)} S \\ e^{j(\varphi_2 - \varphi_1)} S & S + \sigma_N^2 \end{bmatrix} \begin{bmatrix} \alpha_1^* \\ \alpha_2^* \end{bmatrix} = \begin{bmatrix} e^{j\varphi_1} P \\ e^{j\varphi_2} P \end{bmatrix} \\ \Leftrightarrow \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} &= \frac{1}{(S + \sigma_N^2)^2 - S^2} \begin{bmatrix} S + \sigma_N^2 & -e^{j(\varphi_2 - \varphi_1)} S \\ -e^{j(\varphi_1 - \varphi_2)} S & S + \sigma_N^2 \end{bmatrix} \begin{bmatrix} e^{-j\varphi_1} P^* \\ e^{-j\varphi_2} P^* \end{bmatrix} \\ &= \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} = \frac{P^*}{2S + \sigma_N^2} \begin{bmatrix} e^{-j\varphi_1} \\ e^{-j\varphi_2} \end{bmatrix} \end{aligned}$$

in the absence of any timing misalignment, frequency offset or Gaussian noise, the

weighting coefficients are simply,  $\begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} = \frac{1}{2} \begin{bmatrix} e^{-j\varphi_1} \\ e^{-j\varphi_2} \end{bmatrix}$ .

9. (Original) The method of Claim 8, wherein the steps of linearly combining and computing produce an  $\Gamma(\nu)$  that is real and much greater than  $|R_{on}(0)|^2$ , and the result is

$\angle P_{on}^* \cong -2\pi \frac{V}{F_s} 32$  radian, and wherein,  $P^*$  is composed of two phase coefficients, a first one ( $P_{on}^*$ ) centers the frequency offset related phase component around  $Z(32)$ , and the second one ( $P_{\Delta}^*$ ) contains timing-misalignment information.

10. (Original) The method of Claim 9, wherein the steps of linearly combining and computing find  $\bar{Z}$ , and determine the absolute value and sign of the timing misalignment by computing dot products, as in,

$$\gamma_{value} = \frac{|\bar{Z}^H \bar{R}_{on}|}{\|\bar{R}_{on}\|^2} \frac{\lambda_{max}}{\lambda_{max} - \lambda_{min}}$$

where:  $\{\lambda_{max}, \lambda_{min}\} = eig(M^H M)$  with  $M = [\bar{X}_1 \quad \bar{X}_2]$ , and

$$\lambda_{sign} = \text{Re} \left( \bar{Z}^H \frac{\partial \bar{R}_{on}}{\partial t} \right).$$